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NASA TT F-11,324

N67-40120
(ACCESSION NUMBER)
6
(PAGES)
(NASA CR OR TMX OR AD NUMBER)
(THRU)
1
(CODE)
04
(CATEGORY)
FACILITY FORM 602

Translation of "Wplyw Wibracju Na Przemiane Weglowodanowa."
Patologia Polska, Vol. 17, No. 4, pp 565-569, 1966

WARSAW

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D. C. 20546 OCTOBER 1967

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A. Tarnawski*

ABSTRACT. In white rats subjected to vibration, blood sugar levels, blood sugar curves with and without glucose loading, adrenaline and insulin tests, blood levels of lactic acid and glycogen content of the liver and skeletal muscles were determined. These indexes of carbohydrate metabolism revealed distinct deviations from normal: lowered blood sugar levels, lower blood sugar curves after vibration, diminished hyperglycemic action of adrenalin , longer periods of hypoglycemia after insulin, raised levels of lactic acid, and depletion of the glycogen stores in the liver and muscles.

The application of vibrations of a frequency of 180-220 cycles per minute /565** and amplitude of 20-35 mm for 90 minutes every day for three days led to changes in carbohydrate metabolism in white rats. These changes involved the blood sugar and lactic acid level, the glycogen content of the striated muscle and of the liver, the sugar curve with glucose loading, and the adrenalin and insulin tests. With the exception of the changes in the glycogen reserve, the other changes proved to be statistically characteristic.

We often encounter the action of vibration in various situations. It may occur in various means of locomotion and with different work tools and mechanical devices in industrial enterprises.

The body's reaction to vibratory stimulus in the adaptational sense is defined as vibration sickness or vibration syndrome. Andreewa-Gelanina divides these reactions into general reactions and those with a predominance of local changes depending on intensity, local effect, and energy of the vibrational stimulus.

In the most recent literature, (Ref. 1-4) we already find a discussion of vibration complexes, the biological effect of vibration, the type and mechanism of local changes, the participation of the peripheral and central nervous system, and certain biochemical changes in the body provoked by vibration.

Because of the non-exhaustive and non-uniform research which has been done on the effect of vibration on substance metabolism, however, we decided on the basis of our own experiments to find out whether and to what degree vibrations may effect carbohydrate metabolism.

Material and Method

Experiments were conducted on 50 white male and female rats weighing from 150 to 280 gram, coming from the same stock, and kept under optimum environmental conditions and on a normal diet.

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** Note: Numbers in the margin indicate pagination in the original foreign text.

The animals were subjected to vibrations on an apparatus producing vertical oscillations of a frequency of 180-220 cycles per minute at an amplitude of 20-35 mm. Before and after the vibrations, the level of sugar and lactic acid in the blood, as well as the glycogen reserve in the skeletal muscles and liver, was noted. Moreover, to gain a better insight into the dynamics of carbohydrate metabolism, a study was made of the behavior of the sugar curves after glucose loading, and adrenalin and insulin tests were made. The results obtained for the glycogen and lactic acid were compared with their values in control animals. The glucose level and behavior of the sugar curves after the vibrations were, on the other hand, compared with the values determined in the experimental animals before vibration. The time of exposure to vibration varied and is given with each experiment. /566

The blood sugar was determined by the Hagedorn-Jensen method, the lactic acid by the Zacherl-Lieb method, and the glycogen by the Pflüger method.

Results

Sugar level in the blood of 15 rats was ascertained. Before vibration it was from 93 to 123 mg %, with an average value of 110 mg%. After vibration for three days for 90 minutes each day, the blood sugar level was from 76 to 110 mg%, i.e., it averaged 95 mg%. The depressed blood sugar level after vibration exhibited statistical significance ($P < 0.01$). We convinced ourselves that after a single vibration lasting 120 minutes one day the sugar level behaves in a similar fashion. Before vibration, the sugar values in these animals fluctuated from 99 to 111 mg%, i.e., the average value was 107 mg%. After vibration, on the contrary, the sugar values ran from 80 to 86 mg%, i.e., the average value was 82 mg%. In this case, too, the fall in glycemia after vibration was statistically significant ($P < 0.01$).

We noted the sugar curve without loading in white rats on the third day that vibration was applied (90 minutes per day) and confirmed the fact that during vibration on the third day the sugar level rose after one half hour, but after one hour it fell below its original value.

Time in Minutes	0	10	30	45	60
Average Glycemia Value in mg %.	94	108	113	104	86

The sugar curve of 5 animals was taken after the intestines were loaded with glucose in the amount of 1 gram per kilogram of body weight. The same group of animals was then subjected to vibration for 2 days for 90 minutes per day and on the third day, after blood glucose level was determined, glucose was intestinally administered in the same dose as in the controls. Next, the animals were further subjected to vibration and their glucose level determined at 10, 30, 45, and 60 minutes.

		0	10	30	45	60
Control Animals	Average Values in mg %	105	124	144	135	114
Experimental Animals	Average Values in mg%	101	127	147	122	99

It may be noted that in the application of vibrations a more pronounced drop in blood sugar begins to be detected than in the control animals. /567

Epinephrine (adrenalin) in the amount of 0.00025*was subcutaneously administered to 5 white rats, and the blood sugar level was then determined every 15 minutes. Furthermore, in the same animals thereafter subjected to vibration (90 minutes on each of 2 days, and on the third day an epinephrine injection in the same amount as before vibration) the blood sugar behavior was noted after 15, 30, 45, and 60 minutes of vibration.

Time in Minutes	0	15	30	45	60
Average in mg%					
Before Vibration	96	126	153	162	152
After Vibration	90	114	134	150	104

From this comparison it follows that, in the animals subjected to vibrations, the sugaring effect of the epinephrine is less, the highest glycemia level occurs at the same time as without vibration, and after vibration the blood sugar is utilized faster.

In the next group of 10 animals, we conducted an insulin test, injecting five animals each with one half unit of crystalline insulin before vibration, and in the same animals after subjecting them to the effect of vibration in the same way as in the previous group of animals (with epinephrine). Some of the animals of this group (5) were given 0.25 units each of insulin.

Time in Minutes	0	10	30	45	60
Average in mg%					
One Half Unit Before Vibration	98	78	60	50	62
One Half Unit After Vibration	90	80	52	50	40
0.25 Unit Before Vibration	98	87	61	50	55
0.25 Unit After Vibration	97	86	56	43	41

From this comparison, it may be inferred that in the animals subjected to vibration the hypoglycemic effect of the insulin is more accentuated and prolonged. This probably involves the greater utilization of blood sugar in these animals.

We determined the lactic acid level in the blood of a control group of 10 white rats and of 10 rats subjected to vibration for three days for 90 minutes

*Translators Note: Unit not given.

every day, and immediately after the vibration was completed we determined the lactic acid in the blood. In the control animals the average amount of lactic acid was 21.9 mg% (the spread: 17.4 - 28.1 mg%), while, on the other hand, the average was 33.9 mg% in the animals subjected to vibration (the spread: 28.1 - 37.5 mg%). This rise in lactic acid in the animals subjected to vibration is statistically significant ($P < 0.01$).

Finally, we ascertained the glycogen in the liver and skeletal muscles of /568
the control animals and the other animals after three days of 90 minutes of vibration per day. The average liver glycogen value in 11 animals was 951 mg% (the spread: 382 - 2457 mg%) and in 8 animals subjected to vibration the average value was 745 mg% (the spread: 450 - 1280 mg%). The muscle glycogen in 9 control animals averaged 135 mg% (the spread: 80 - 267 mg%), while in 7 animals subjected to vibration it was 99 mg% (the spread: 47 - 182 mg%).

Conclusions

1. In white rats subjected to rather long vibration of an initially set frequency and amplitude, there is a marked, statistically significant reduction in blood sugar level after an initial growth, for a maximum of about 30 minutes of vibration action.

2. During the vibration there is a marked, statistically significant rise in the level of the blood lactic acid.

3. The sugar curves during vibration without and after loading exhibit a tendency to lower; the adrenalin test after vibration indicates weaker sugaring action on the part of adrenalin; the insulin test in the animals subjected to vibration shows a protracted period of hypoglycemia in comparison with the control curves.

4. In animals subjected to vibration, there is a reduction in the glycogen reserves of the liver and muscles, but as this was done for a small number of animals and large individual differences there is no statistical significance.

5. From out investigations, we found that vibration has a marked disadvantageous effect on carbohydrate metabolism.

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NASw 1496